Bioprospecting in Extreme Environments

Tamas Torok, Center for Environmental Biotechnology
Contact: 510/486-5808 ttorok@lbl.gov)

RESEARCH OBJECTIVES AND SIGNIFICANCE

Extremophilic microorganisms are adapted to survive in such ecological niches as high temperatures, extremes of pH, high salt concentrations, and high pressures. Therefore, extremophilic microorganisms represent a challenging scientific opportunity, not only for those interested in microbial diversity and the evolution of life, but for researchers searching for clues to extraterrestrial life. Also, extremophiles produce unique biocatalysts that function under extreme conditions comparable to those prevailing in various industrial processes. Bioprospecting for extremophiles with potential immediate use in the food, chemical, and pharmaceutical industries—and in environmental biotechnology—is therefore highly relevant.

In fulfilling the national security and biological nonproliferation missions of the U.S. Department of Energy, the main objective of this research is to establish a multiyear bioprospecting program for novel biotechnology applications in the extreme environments of the Newly Independent States (NIS) of the former Soviet Union. In previous years, the program collected environmental samples in the exclusion zone of the failed nuclear power plant in Chernobyl, around Lake Baikal in Siberia, and on the Kamchatka peninsula. Currently, we are expanding our research to the deserts and hot springs in Uzbekistan, the Caucasus mountain sites in Georgia, and the former nuclear test site in Kazakhstan.

APPROACH AND RESULTS

Structure of the microbial community in an ecological niche is characteristic for the ongoing biogeochemical processes. We use a polyphasic approach to microbial community characterization—i.e., both culture-based and alternative, nonculture-based techniques. We have isolated several thousand new microbial strains and detected novel restriction enzymes (as well as unique combinations thereof). Isolated microorganisms are then grown under proprietary, secondary metabolite-producing conditions, and the resulting natural products are screened for innovative crop protection and biomedical application in collaboration with our biotech industry partners. Lead molecules are chemically characterized. Nucleic acid sequences of interest extracted from extreme environmental samples are used in recombinant technologies and lead to novel biocatalysts and biologically active molecules, with a wide range of applications in industry, agriculture, and medicine. Microorganisms and their natural products are being protected by joint patent disclosures. Berkeley Lab is licensing the cultures to the industrial partners. Royalties and other benefits are equitably shared with the NIS researchers.

ACKNOWLEDGMENTS

This program has been supported by DOE's Initiatives for Proliferation Prevention (IPP) program. The author wishes to express his deepest appreciation for the support he received from colleagues at the International Institute of Cell Biology, Kiev, Ukraine; the State Research Center of Virology and Biotechnology, "VECTOR", Koltsovo, Novosibirsk region; the Institute of Volcanology, Petropavlovsk-Kamchatsky, a member of the Far East Branch of the Russian Academy of Sciences (RAS); the Institute of Geochemistry of the RAS, Irkutsk; and the Buryat Institute of Geology in Ulan Ude, Russia. Special thanks are due to the Baikal Drilling Project and the members of the Russian drilling crew for their professional understanding and support. Special thanks are extended to G. Dahlbacka, Berkeley Lab's ILAB representative. Without his active support, this program could not have achieved its goals.